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EXCLUSIVE TWO-PHOTON PRODUCTION OF OMEGA-OMEGA MESON PAIRS

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ABSTRACT

Using the CLEO-II detector, we have studied the two-photon production of $\omega\,\omega$ meson pairs in untagged reactions. We report on preliminary measurements of $\omega\,\omega$ production at two-photon centre-of-mass energies from $1.5-3.5\,\mathrm{GeV}$. No structure is observed in the $\omega\,\omega$ effective mass plot.

1. Introduction

In this paper we present the two-photon production of $\omega\,\omega$ meson pairs in untagged reactions at two-photon centre-of-mass energies from $1.5-3.5\,\mathrm{GeV}$. This study is a continuation of a program to study the two-photon production of meson pairs. Results on $\gamma\gamma\rightarrow\pi^+\pi^-, K^+K^-$ obtained since the 1992 Workshop have been published[1]. The two-photon production of $\omega\,\omega$ has been observed by ARGUS[2] who reported a possible enhancement in the $\omega\,\omega$ effective mass plot near $1.9\,\mathrm{GeV}$. Broad enhancements are expected for example in models of four-quark bound states that decay into $\omega\,\omega$ pairs.

The reactions are observed in the CLEO-II detector at the Cornell Electron Storage Ring (CESR) high luminosity e^+e^- collider operating at centre-of-mass energies near $10.5\,\mathrm{GeV}$. The $\omega\,\omega$ channel is detected through the $\omega\rightarrow\pi^+\pi^0\pi^-$ decay mode.

2. Detector and Data Sample

The measurement described here utilizes data collected with the CLEO-II general purpose magnetic detector. A brief description of the CLEO-II detector[3] and its trigger system[4] can be found in these proceedings[5]. In the present analysis the three cylindrical driftchambers are used for the tracking of charged pion candidates while the electromagnetic calorimeter is used to reconstruct pizeros from photon pairs. Among the triggers used are the two-track trigger discussed already[5] and a multihadron trigger that requires that at least three tracks have been recognized by a tracking processor. The datasample corresponds to an integrated luminosity of $3.02\,\mathrm{fb}^{-1}$.

3. Event Selection

The event selection identifies $\omega\,\omega$ pairs through the $\omega\rightarrow\pi^+\pi^0\pi^-$ decay channel. Events are required to have four tracks with total charge equal zero and two or three pizeros. Two-photon produced events are selected by requiring that the visible energy be less than $6\,\mathrm{GeV}$ (out of a maximum of $10.5\,\mathrm{GeV}$) and that the absolute value of the cosine of the angle between the missing momentum and the beam be greater than 0.9. The latter condition requires that the missing energy is directed mostly along the beam direction as it should be for two-photon events. The ω in exclusively produced $\omega\,\omega$ pairs must be approximately

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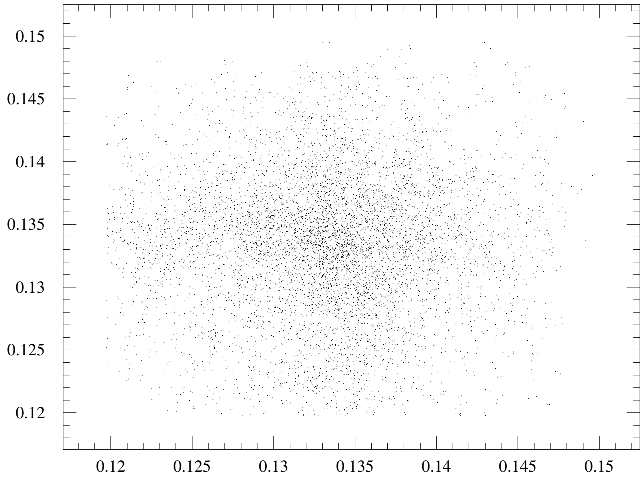

Fig. 1. Scatterplot of the effective mass of one photon pair versus another photon pair.

back-to-back in the plane transverse to the beam so we require that the acoplanarity (the deviation from back-to-back, measured in radians) be less than 0.45. The events are required to have been triggered by the two-track trigger or the hadron trigger, or both.

Pizeros are found by forming the effective mass of all pairs of electromagnetic showers in the electromagnetic calorimeter. The energy of the showers has to be larger then 30 MeV in the barrel and larger then 80 MeV in the endcap and larger than 50 MeV in the overlap region. If the effective mass is within 50 MeV of the nominal pizero mass, the effective mass is fit to the nominal mass by varying the energy and position of the two photons. If the fit passes a χ^2 cut, the photon pair is assigned to a pizero and they are not used again in the search for other pizeros. Fig. 1 is a scatterplot of the effective mass of one photon pair versus another photon pair. A clear pizero-pizero enhancement is visible. We select pizero-pairs by selecting events in the scatterplot within a circle 15 MeV radius centered upon the pizero-pizero mass.

All possible pairs of $\pi^+\pi^0\pi^-$ triplets are formed. We show in Fig. 2 a scatterplot of the effective mass of one triplet versus another. Clear ω bands are visible.

4. Signal Extraction

An $\omega\,\omega$ signal is present if the number of events at the crossover point in Fig. 2 is more than the sum of the events expected there from an extrapolation from the nearby region of each of the bands. To determine if such an excess exists, a new method has been used. In this method the average of two triplet masses is formed. This is done for each pair of triplets. To reduce background, the two ω bands in Fig. 2 are selected by requiring that at least one of the two triplet masses is in the interval $750 - 810$ MeV. A study using simulated events in each of the three categories $\omega\,\omega$, $(\pi^+\pi^0\pi^-)\omega$ ($\pi^+\pi^0\pi^-$ means non-resonant), and $(\pi^+\pi^0\pi^-)(\pi^+\pi^0\pi^-)$ shows that only the $\omega\,\omega$ final state leads to a peak in the average mass

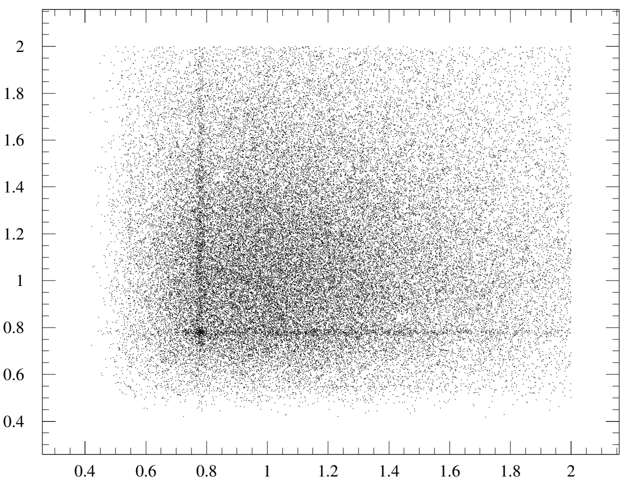

Fig. 2. Scatterplot of the effective mass of one $\pi^+\pi^0\pi^-$ triplet versus another $\pi^+\pi^0\pi^-$ triplet.

spectrum. The peak is located at the ω mass.

This method is applied to the data in 250 MeV W bins where W is the effective mass of the $(\pi^+\pi^0\pi^-)(\pi^+\pi^0\pi^-)$ final state. Fig. 3 shows some of the average mass distributions for the indicated W bins. The distributions are fit to a Gaussian for the $\omega\,\omega$ peak and a third order polynomial for the background. The signals in the lowest and highest W bin are not significant. The total number of $\omega\,\omega$ events is approximately 70.

5. Event Simulation and Cross Section

The event simulation consists of two parts: event generation and detector simulation.

Two-photon events are generated using the BGMS[6] formalism. In this formalism the inclusive differential cross section for $e^+e^- \to e^+e^-X$ is written as the sum of four cross sections and two interference intensities. The latter two drop out when integrating over the azimuthal angles of the scattered electron and positron, defined relative to the beam axis. Three of the four cross sections involve at least one scalar photon. These terms can be neglected for untagged two-photon reactions where the photons are quasi-real and thus essentially transverse. The one non-zero term describes the collision of two transverse photons. It is expressed as the product of two photon-fluxfactors and a photon-photon cross section $\sigma(\gamma\gamma \to X)$. The two photon-fluxfactors in this term are each multiplied by a ρ-formfactor as in Vector Meson Dominance (VMD). The state X corresponds to the $\omega\,\omega$ final state, the ω are produced isotropically in the $\gamma\gamma$-CM. The $\omega \to \pi^+\pi^0\pi^-$ decay is generated according to the known ω decay.

The CLEO-II detector response, including the trigger, is simulated with CLEOG, a GEANT based package that generates raw data for each detector element in the same format as the real data. The data from simulated events is processed through the same event reconstruction software and analyzed by the same analysis program as the real data.

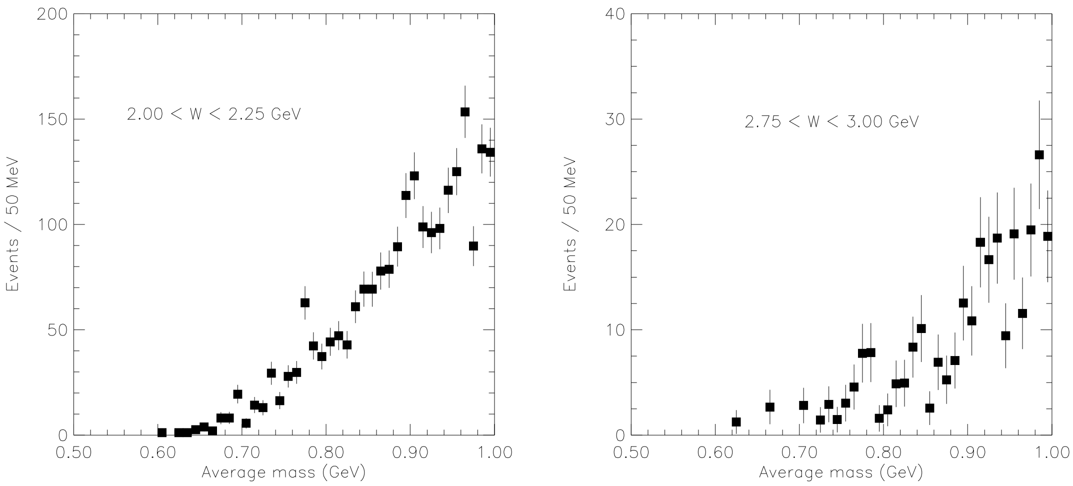

Fig. 3. Average mass distributions for data in two bins of W.

The resulting two-photon cross section $\sigma(\gamma\gamma \to \omega\,\omega)$ is plotted in Fig. 4 as function of W. W corresponds to the two-photon centre-of-mass energy. If some $\omega\,\omega$ pairs are produced by the decay of a parent particle, a corresponding enhancement would show up in the W distribution. There is no evidence of an enhancement in Fig. 4. The cross section is seen to be of the same order of magnitude as the $\gamma\gamma \to \pi^+\pi^-$ cross section[1]. The cross section agrees with the one reported by ARGUS[2] for $W > 2\,\mathrm{GeV}$ but disagrees at lower W. In particular, no enhancement is seen near 1.9 GeV.

The systematic error is estimated to be 10-15%. Major contributions are from the background in the fit of the ω plus background to the data in the average mass plots (8%), the trigger efficiency (5%), the tracking efficiency (5%), the W dependence used in the event simulation (4%), and the VMD formfactors used (3%). The systematic error on the trigger efficiency was determined by comparing the trigger efficiency measured from the data (by using a looser prescaled trigger) with the efficiency predicted from the event simulation.

6. Conclusions

We report preliminary results of a study of two-photon production of $\omega\,\omega$ meson pairs with the CLEO-II detector at CESR. Approximately 70 events have been observed in the W range from 1.5 to 3.5 GeV for an integrated luminosity of $3.02\,\mathrm{fb}^{-1}$. No enhancements are observed in the W distribution.

1. J. Dominick *et al.* (CLEO Collaboration), *Phys. Rev.* **D50** (1994) 3027.
2. H. Albrecht *et al.* (ARGUS Collaboration), *Phys. Lett.* **B198** (1987) 577.
3. Y. Kubota *et al.* (CLEO Collaboration), *Nucl. Inst. and Meth.* **A320** (1992) 66.
4. C. Bebek *et al.* (CLEO Collaboration), *Nucl. Inst. and Meth.* **A302** (1992) 261.
5. V. Savinov, A Measurement of the Form Factors of Light Pseudoscalar Mesons at a Large Momentum Transfer, these proceedings.

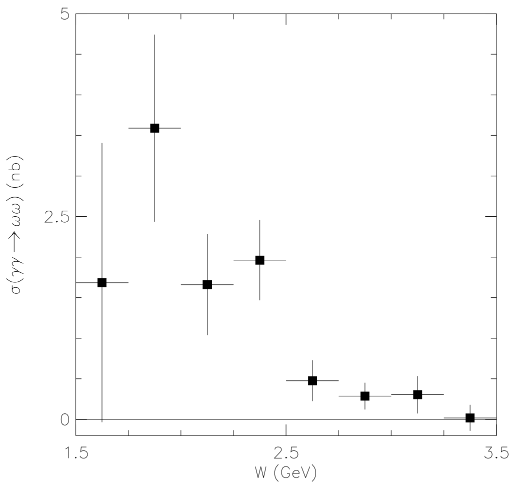

Fig. 4. The cross section $\sigma(\gamma\gamma \to \omega\,\omega)$ as function of W.

6. V.M. Budnev *et al.* (BGMS), *Phys. Rep.* **C15** (1975) 181.